Executive Summary

Rocky Mountain Remediation Services, L.L.C. (RMRS) has developed Envirobond™ to reduce the mobility of metals in soils. During September 1998, an *in situ* application of the technology was demonstrated under the U.S. Environmental Protection Agency's (EPA) Superfund Innovative Technology Evaluation (SITE) Program on soil contaminated with lead at two sites in Roseville, Ohio.

The purpose of this innovative technology evaluation report (ITER) is to present information that will assist Superfund decision makers in evaluating Envirobond™ for application at a particular hazardous waste site. This report provides an introduction to the SITE program and Envirobond™ and discusses the demonstration objectives and activities (Section 1); evaluates the technology's effectiveness (Section 2); analyzes key factors related to application of the technology (Section 3); analyzes the costs of using the technology to reduce the mobility of lead in soil, as well as the soil lead bioaccessibility (Section 4); summarizes the technology's current status (Section 5); and presents a list of references.

This executive summary briefly summarizes the information discussed in the ITER and evaluates the technology with respect to the nine criteria applied in Superfund feasibility studies.

Technology Description

RMRS claims that the Envirobond™ process can bind with metals in contaminated soils, sludges, mine tailings, process residuals, and other solid wastes. RMRS further claims that the Envirobond™ process converts each metal contaminant from its leachable form to a stable, nonhazardous metallic complex. The Envirobond™ process is a mixture of ligands that act as chelating agents. In the chelation reaction, coordinate bonds attach the metal ion to at least two ligand nonmetal ions to form a heterocyclic ring. By effectively binding the metals, RMRS claims that the Envirobond™ process reduces the waste stream's Toxicity Characteristic Leaching Procedure (TCLP) test results to less than the regulated levels, subsequently reducing the risks posed to human health and the environment.

Overview of the SITE Demonstration

The SITE demonstration of Envirobond™ was conducted in September 1998 at two sites in Roseville, Ohio: an inactive pottery factory and a trailer park. Both sites are located in the Crooksville/Roseville Pottery Area of Concern (CRPAC). Historically, the CRPAC was a major pottery manufacturing area. Lead was used in the glazing process of the pottery finishing process; as a result, has contaminated the upper portion of the soil layer. Soil samples collected by the Ohio Environmental Protection Agency (OEPA) in 1997 indicated that elevated levels of lead were present in the CRPAC. Waste disposal practices and residue from the operation of the kiln at the inactive pottery factory may have contributed to contamination of the soil adjacent to the factory. Waste from several pottery factories in the CRPAC was used as fill material in the vicinity of the trailer park. The fill material may be the source of the lead contamination of the soil at the trailer park.

For the SITE demonstration, soil samples were collected before and after application of Envirobond™ to evaluate whether the technology could achieve the treatment goals of the demonstration project. The project had two primary objectives and four secondary objectives.

The primary objectives of the SITE demonstration were

- Primary Objective 1 (P1) - Evaluate whether Envirobond™ can treat soils contaminated with lead to meet the Resource Conservation and Recovery Act (RCRA)/Hazardous and Solid Waste Amendments (HSWA) alternative universal treatment standard (UTS) for land disposal of soils contaminated with lead that meet the definition of a hazardous waste. The alternative UTS for lead in such soil is determined from the results of the toxicity characteristic leaching procedure (TCLP). The alternative UTS for lead is met if the concentration of lead in the TCLP extract is no higher than one of the following: (1) 7.5 milligrams per liter (mg/L), or (2) 10 percent of the lead concentration in the TCLP extract from the untreated soil. The alternative UTS is defined further in Title 40 of the Code of Federal Regulations (CFR), Chapter I, part 268.49 (40 CFR 268.49).

- Primary Objective 2 (P2) - Evaluate whether Envirobond™ can decrease the soil lead bioaccessibility by 25 percent or more, as defined by the Solubility/Bioaccessibility Research Consortium's (SBRC) In-Vitro Method for Determination of Lead and Arsenic Bioaccessibility (simplified in-vitro method [SIVM]) (Note: the EPA Lead Sites Workgroup (LSW) and Technical Review Workgroup for lead (TRW) at this time do not endorse an in vitro test for determining soil lead bioaccessibility [ITRC 1997]).

The secondary objectives of the demonstration were

- Secondary Objective 1 (S1) - Evaluate the long-term chemical stability of the treated soil.

- Secondary Objective 2 (S2) - Demonstrate that the application of Envirobond™ did not increase the public health risk of exposure to lead.

- Secondary Objective 3 (S3) - Document baseline geophysical and chemical conditions in the soil before the application of Envirobond™.

- Secondary Objective 4 (S4) - Document the operating and design parameters of Envirobond™.

SITE Demonstration Results

Summarized below are the significant results of the SITE demonstration:

- Envirobond™ reduced the mean TCLP lead concentration from 382 mg/L to 1.4 mg/L at the inactive pottery factory, a reduction of more than 99 percent. Therefore, the treated soil meets the alternative UTS for soils contaminated with lead, as specified at CFR 268.49. Data from the trailer park were not used to evaluate P1 because TCLP lead concentrations in all treated and untreated soil samples from this location were either at or slightly higher than the detection limit of 0.05 mg/L.

- Analysis of the data generated by application of the SIVM demonstrated that Envirobond™ reduced the soil lead bioaccessibility by approximately 12.1 percent. However, it was recognized early on that meeting this goal would be difficult because the SIVM test procedure used in the demonstration involves a highly acidic sample digestion process, which may be revised in the future, because it may be exceeding the acid concentrations that would be expected in a human stomach.

- Soil treated with Envirobond™ appears to exhibit long-term chemical stability, as indicated by the results of most of the 11 analytical procedures that were conducted to predict the long-term chemical stability of the treated soil. However, the results of some of the analytical procedures suggest that Envirobond™ does not appear to exhibit long-term chemical stability. In summary:

  — Long-term soil chemical stability was indicated for soils treated by Envirobond™ at both test locations, as indicated by the analytical results of the multiple extraction procedure (MEP), the procedure for lead speciation by sequential extraction, the test for cation exchange capacity (CEC), and leachable lead by the simulated precipitation leaching procedure (SPLP). The CEC results are considered to be qualitative, because this test was conducted on only a single sample from each location.

  — Long-term chemical stability was indicated at one site, but not at the other, by the analytical results of procedures for evaluating acid neutralization capacity. The acid neutralization results are considered to be qualitative, because this test was conducted on only a single sample from each location.

  — The analytical results from the lead speciation test by scanning electron microscopy (conducted only on soils from the trailer park) were mixed, in that the silica phosphate phase (low solubility) of lead was increased and some soluble phases of lead were reduced, while other low-solubility phases of lead were also reduced.

  — At both locations, long-term chemical stability was not indicated for soils treated by Envirobond™ by the results of the pH analyses, Eh analyses, separate analyses for total lead by nitric and hydrofluoric acids; total phosphates; and SPLP phosphates (It should be noted that the tests involving two types of total lead analysis were extremely aggressive tests, thus meeting the acceptance criteria established for these tests was not as important as meeting the acceptance criteria of other tests involving long-term chemical stability).

- As the analytical results for the air samples demonstrated, the dust generated during site preparation activities prior to the application of Envirobond™ may exceed the National Ambient Air Quality Program Standard for lead of 1.5 micrograms per cubic meter of air. Therefore, if it is determined that it is necessary to remove the soil or use other techniques that might generate

dust, it is recommended that air monitoring (with real-time devices correlated to actual lead concentrations in the air) be employed; and, if necessary, dust suppression measures also should be employed.

- Based on visual observations during the demonstration, the application of Envirobond™ does not appear to create significant quantities of dust.

- On the basis of information obtained from the SITE demonstration, RMRS, and other sources, an economic analysis examined 12 cost categories for a scenario in which Envirobond™ was applied at full scale to treat 807 cubic yards (yd^3) of soil contaminated with lead at a 1-acre site at CRPAC. The cost estimate assumed that the concentrations of lead in the soil were the same as those encountered during the Roseville demonstration. On the basis of those assumptions, the cost was estimated to be $41.16 per yd^3 of treated soil, which is a site-specific estimate.

Superfund Feasibility Study Evaluation Criteria for the Envirobond™ Process

Table ES-1 presents an evaluation of Envirobond™ with respect to the nine evaluation criteria used for Superfund feasibility studies that consider remedial alternatives for superfund Sites.

Table ES-1. Evaluation of Envirobond™ by Application of the Nine Criteria for Superfund Feasibility Studies

Criterion		Discussion
1.	Overall Protection of Human Health and the Environment	The technology is expected to significantly lower the leachability of lead from soils as indicated by the TCLP results, thereby reducing the migration of lead to groundwater and the potential for exposure of all receptors to lead; however, the technology did not significantly reduce soil lead bioaccessibility, as determined by the SIVM.
2.	Compliance with Applicable or Relevant and Appropriate Requirements (ARAR)	During the SITE demonstration, Envirobond™ reduced the mean TCLP lead concentration from 382 mg/L to 1.4 mg/L, a reduction of more than 99 percent. Further, the treated TCLP lead concentrations were less than the alternative UTS for lead in soil. Therefore, the treated soil met the land disposal restrictions (LDR) for lead-contaminated soil, as specified in 40 CFR 268.49. However, the technology's ability to comply with existing federal, state, or local ARARs should be determined on a site-specific basis.
3.	Long-term Effectiveness and Permanence	The analytical results of procedures for the multiple extraction procedure (MEP), the procedure for lead speciation by sequential extraction, the test for cation exchange capacity (CEC), and leachable lead by the simulated precipitation leaching procedure (SPLP) suggest long-term chemical stability of the treated soil. The analytical results of a number of other procedures do not suggest long-term chemical stability of the treated soil. Those procedures included pH analyses, Eh analyses, separate analyses for total lead by nitric and hydrofluoric acids; total phosphates; and SPLP phosphates. The results related to long-term effectiveness from the test for lead speciation by scanning electron microscopy and acid neutralization were inconclusive.
4.	Short-term Effectiveness	Short-term effectiveness is high; measures to control dusts and surface runoff controls may be needed at some sites.
5.	Reduction of Toxicity, Mobility, or Volume Through Treatment	The mean TCLP lead concentration was reduced from 382 mg/L to 1.4 mg/L, reducing the mobility of the lead in the soil.
6.	Implementability	The technology is relatively easy to apply. Large areas can be treated using common farm equipment, and small areas can be treated using readily available home gardening tools (sod cutter, tiller, fertilizer sprayer).
7.	Cost	For full-scale application of the technology at a 1-acre site contaminated with lead in the top 6 inches of soil, estimated costs are $33,220, which is $41.16 per cubic yard.
8.	Community Acceptance	Community acceptance of Envirobond™ likely will be a site-specific issue.
9.	State Acceptance	State acceptance of Envirobond™ likely will be a site-specific issue.